Romeo Sierra calls Papa Tango – atmospheric pressure plasma for secure airborne communication

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Passenger safety depends to a large extent on clear communication between air traffic controllers and pilots. In order to ensure the reliable adhesion of the conformal coating of the plastic-encapsulated airborne communication assemblies, the highly sensitive electronic components are pretreated with atmospheric plasma.

The safety of billions of air travellers depends on uninterrupted radio communication between air traffic controllers and pilots

(Photo: Rohde & Schwarz)

According to the International Civil Aviation Organization (ICAO) Air Transport Results 2013, more than three billion civilian air passengers relied on the quality and reliability of air traffic control systems during the previous year. The main task of air traffic controllers is to guide aircraft on the ground and in the air by radio to prevent collisions. This communication is itself reliant on the correct functioning of electronic aircraft radio systems.

Crews on long haul flights use shortwave radios to communicate with air traffic control, and to stay in touch with their airlines from anywhere in the world. These devices allow uninterrupted communication even on routes over the poles where satellite networks cannot be used.

Rohde & Schwarz, a leading manufacturer of wireless communications and EMC test and measurement equipment and broadcasting and T&M equipment for digital terrestrial television, also manufactures these airborne radios, which are required to meet the highest safety standards. These high-tech systems are produced by the subsidiary Rohde & Schwarz Messgerätebau GmbH at its manufacturing plant in Memmingen, Germany, which is responsible for assembly, final testing and shipping of almost all the company's products. Barely a single long-haul aircraft in the world lands or takes off without the assistance of an XK/FK 516 shortwave radio produced by this specialised Bavarian company.

At the core of the FK 516 antenna tuner developed specifically for civilian airborne radio communication and long-haul flights is the tuning control unit; a circuitboard fitted with several hundred tiny plastic-encapsulated surface-mounted devices (SMDs). The function of this SMD assembly is to reliably tune the antennae, thereby ensuring overall radio communications.

Unexpected adhesive problem

Conformal coating, a production process which the company had been using without a hitch for several years, was disrupted when it was discovered that the transparent protective coating had lifted on around 50 transistors. Since nothing whatsoever had changed in the assembly, pre-cleaning or coating process, the root of the problem could only lie with the component material itself. When questioned, the supplier confirmed that it had changed the composition of its plastic blend.

This is a problem frequently encountered by processing companies that are reliant on plastic components produced externally. Even the slightest alteration to the composition can be enough to totally change the surface characteristics of the material. The situation was exacerbated by the fact that there was no alternative to the new plastic blend. There was no other certified manufacturer available who could produce these particular electronic components. "We had to find a solution as quickly as possible to ensure the adhesion of the conformal coating," explained Michael A Schneider, mechatronics engineer in charge of production technology at Rohde & Schwarz. "Without a reliable adhesive bond it would no longer be feasible to continue manufacturing the tuning control units."

Surface activation

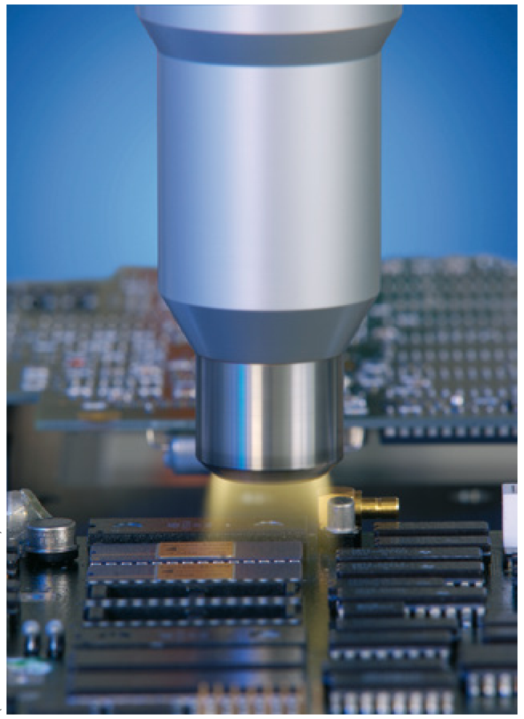
Materials are made more receptive to adhesion by means of 'activation'; in other words, by pretreating them so as to increase their surface energy (See Figure 1 on page 24). This is the most important measure for determining the probable adhesion of an adhesive layer or coating. Various pretreatments are available to achieve these two conditions, with wet chemical substances still the most widely used.

Difficult search

But finding the right pretreatment for these highly sensitive electronic components seemed almost impossible at first. Schneider commented: "Activation using a solvent-based primer was not an option for us. Partly because these substances are extremely harmful to the environment, and partly because they would incur enormous costs in terms of health and safety (eg, explosion protection) and disposal. The electronic engineers also ruled out laser pretreatment on the grounds that the uneven surface of the material would have made the coupling efficiency unpredictable. CO_2 snow blasting, which cleans but has no activation capability, was also rejected. The final method under consideration was a low-pressure plasma treatment; a highly effective activation process, but not suitable for this purpose because the vacuum would have drawn the fluid out of the wet electrolytic capacitors contained in the SMD assembly. "We seemed to be very far from finding a way round this problem," recalled the engineer, "but then I stumbled across a solution at an automation trade fair. This is where I discovered atmospheric pressure plasma; or more precisely, Openair plasma jet technology."

The solution

The pretreatment process developed by Plasmatreat GmbH, Steinhagen, back in the mid-'90s is now used throughout the world in almost every branch of industry. The environmentally friendly in-line technology works under normal



(Photo: Plasmatreat)

Figure 1: The rotating Openair plasma jet strongly activates the plastic components in a matter of seconds without damaging the sensitive electronics.

(Photo: Plasmatreat)

Figure 2: Avionics specialist Michael Schneider (left) and plasma expert Peter Langhof (right) standing in front of the Openair plasma equipment.

ambient air conditions, thereby dispensing with the need for a vacuum chamber.

Peter Langhof, market and project manager at Plasmatreat (Figure 2), explained: "Openair plasma performs two operations in a single step lasting only a matter of seconds: it simultaneously brings about the microfine cleaning and strong activation of the plastic surface." The rise in temperature of the plastic surface during plasma treatment is typically less than 30 °C and substrates can be transported through the plasma jet at speeds of several hundred metres per minute. “For electronic components, we use patented rotational nozzles with a special gentle action,” Langhof continued. Schneider was soon convinced of the plasma’s powers of activation, but the manufacturing specialist had one new question: “Would the sensitive electronics survive the plasma treatment unscathed?”

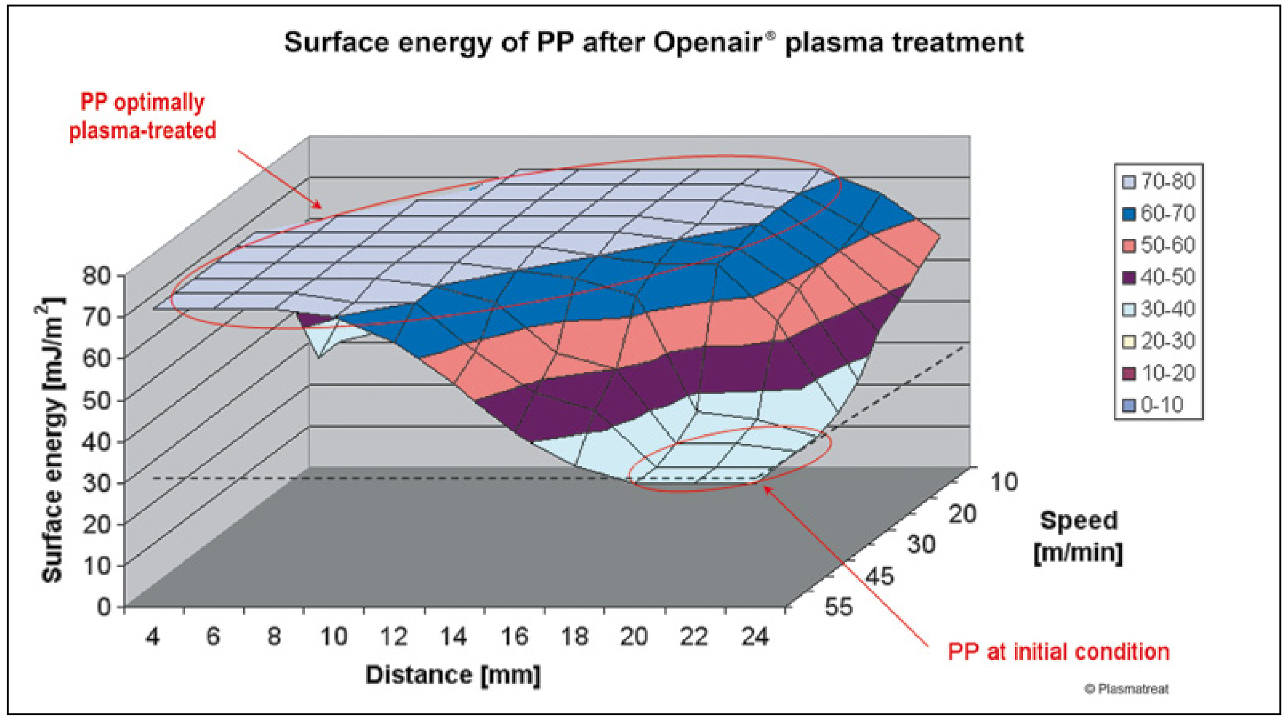
It was clear from the very first tests performed on an Openair system supplied on loan that the plasma had not damaged the electronics. The surface energy of the plastic transistors which had caused the whole problem increased from below 30 dyne in the inactivated state, to over 70 dyne following plasma treatment. The final visual UV inspection which every single SMD component undergoes before assembly, also showed that there was not a single area where the coating had lifted (Figure 3). But for Rohde & Schwarz this was not sufficient proof. The most challenging test still lay ahead.

Endurance test proves suitability for continuous operation

The aviation industry’s requirements regarding the integrity and service life of safety-relevant components far outweighs those of the automotive industry, whose requirements are themselves recognised as being very tough. One example of this is the Burn-In test which is performed post-production on tuning controls at Rohde & Schwarz. This test requirement results from the fact that airborne radios are rarely installed in the plane’s air-conditioned and pressurised engine area. Most are located in the nose of the aircraft where very different temperature and humidity conditions prevail. This is why it is so important to ensure that the protective coating is fully bonded to the electrical components. Even the smallest leak would result in moisture ingress, potentially leading to complete failure of the radio communications system. What most air passengers don’t realize is that all passenger planes are obliged to carry two sets of radio equipment on board; the second as backup in case the first one fails. If a plane lands at its destination with a defective radio system, it has to wait on the tarmac until a spare radio set has been acquired and fitted.

The purpose of the Burn-In test is to investigate continuous operation and accelerated ageing of electronic components. It is the toughest load test available for electronic circuit boards and is used to detect manufacturing faults which were not picked up earlier as well as to identify components that would fail in continuous operation.

At Memmingen,Burn-In is performed on the finished radios (Figure 4) under operating conditions, ie, powered up and with antennae. The test consists of a series of eight-hour cooling and heating cycles; after a four-hour cooling cycle at -55 °C,the temperature in the burn-in chamber is pushed up to +70 °C in a matter of a few minutes and held for a further four hours before plunging back down equally rapidly to start the next cooling cycle. These cold/warm cycles are repeated nine times, amounting to three days. In that period of time the airborne radio faces a non-stop exposure to rapid and extreme temperature variations. If the plasma had damaged the electronics, the components



(Diagram: Plasmatreat)

Figure 3: The diagram shows a non-polar plastic surface which was pretreated with plasma as a function of distance and speed. Treatment renders the surface polar and the surface energy rises to >72 dyne with a large process window.

would eventually have failed during this test. It would equally have become apparent if the coating had been poorly bonded to the plastic.

Summary

Even after this test, the results were conclusive: the electronics function perfectly and the coating adhesion is long-time stable. The plasma technology provided by Plasmatreat has proven its worth in all areas and under the most challenging conditions. The Memmingen-based airborne communications specialist has returned the borrowed equipment and purchased its own, which is now running in continuous production and playing its part in ensuring radio safety.

“We greatly value the high degree of process reliability afforded by this technique and its effective monitoring capabilities. These two factors, combined with the user-friendly design, were what persuaded us to choose this system,” explained Michael Schneider, before adding: “This plasma technology has enabled us not only to reduce the number of process steps but also to enhance the quality of our product within a very short space of time.” ∎

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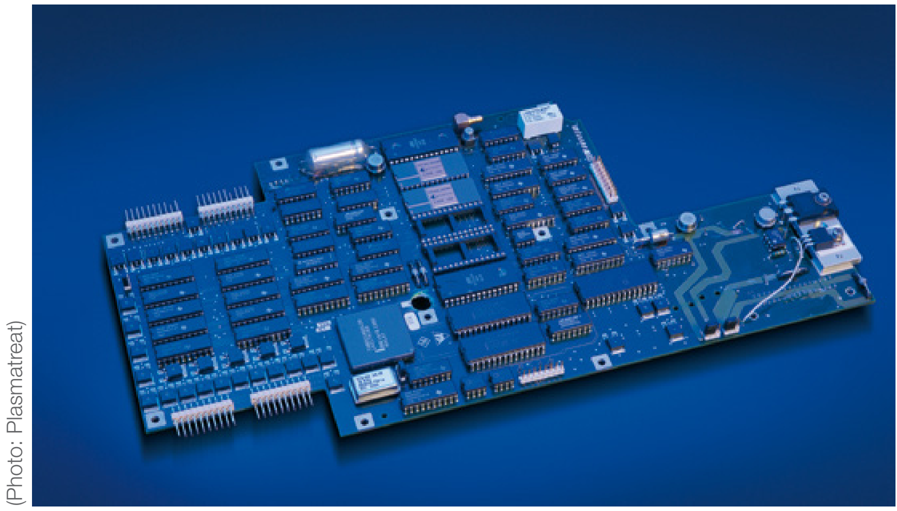

(Photo: Plasmatreat)

Figure 4: The coating’s adhesive bond is visually inspected under UV light before the SMD assembly is mounted in the radio. Then a Burn-In test is performed to verify its stability.

(Photo: Rohde & Schwarz)

Figure 5: The XK / FK 516 shortwave radio guarantees airborne communications: left, the FK 516 antenna tuning unit with built-in tuning control; right, the matching amplifier.